QUESTION 92○○

How can case studies be used for brain research?

2 marks

QUESTION 93○○

What are some of the major problems with the use of case studies for brain research?

2 marks

QUESTION 94○○

How does an electroencephalograph (EEG) work?

2 marks

QUESTION 95○○○

Describe the method used by Penfield and his associates to investigate the functions controlled by various cerebral structures.

2 marks

QUESTION 96○○○

What occurs in the process of transcranial magnetic stimulation (TMS)?

QUESTION 97○○○

Describe the process of computerised tomography (CT scan) in terms of its use in brain research.

QUESTION 98○○○

What is the main purpose of using a single photon emission computed tomography (SPECT) scan in brain research?

QUESTION 99○○○

What is involved in a positron emission tomography (PET) scan?

3 marks

QUESTION 100○○○

Clarify the role of an fMRI scan in brain research.

3 marks

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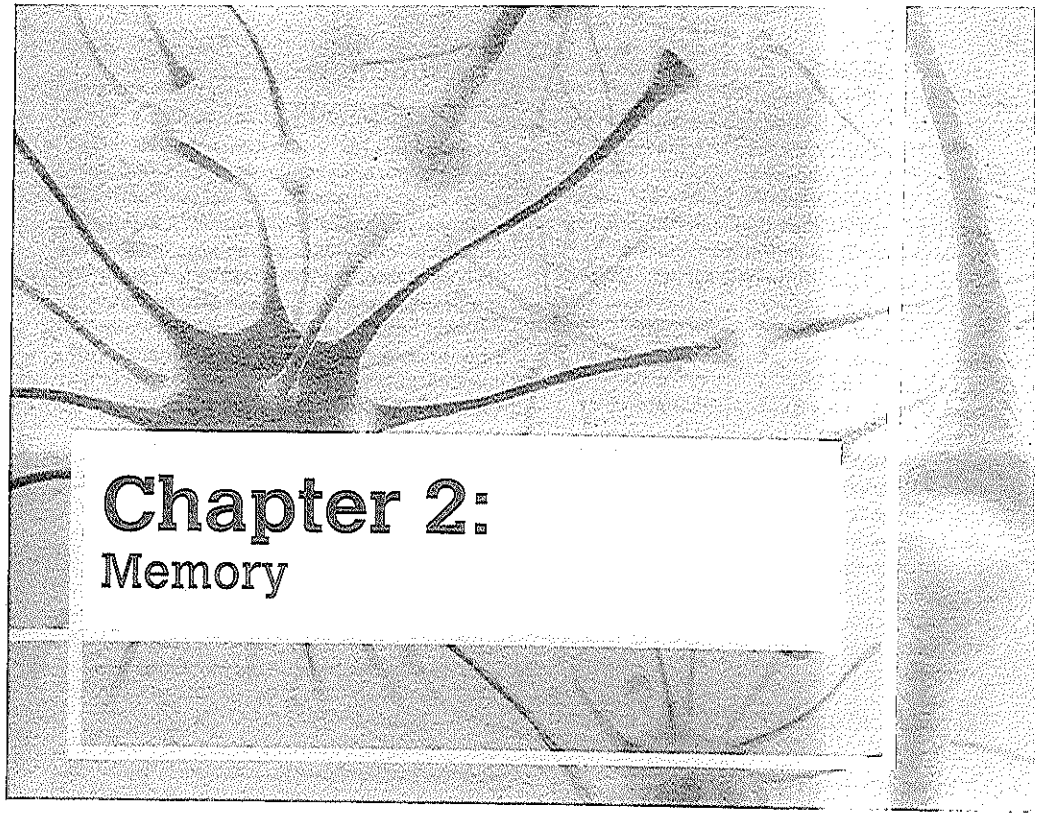

Chapter 2: Memory

The role of the nervous system in memory

The role of the neuron in memory formation (Kandel, 1965, 2000)

Invertebrates have fewer neurons and much simpler nervous systems than vertebrates and yet can display complex forms of learning, such as associative conditioning. As such, they have provided valuable models for studies into the cellular and molecular mechanisms of learning and memory.

Since the 1960s, Kandel's research has centred on the sea mollusc *aplysia* (or *sea hare*). This species has relatively few nerve cells (approx 20 000), many of them very large and therefore easy to study, enabling Kandel and his team to identify, through stimulation, various types and groups of neurons involved in aplysia's behaviour. Identification of the neuronal connections allowed the researchers to examine which components of the neural circuits changed during learning, as well as the molecular mechanisms responsible for the changes in neuronal function.

The *aplysia* has a protective siphon withdrawal reflex to guard its gills, which Kandel used as the focus of his study into the basic learning mechanisms. In activating this reflex over and over again, the synaptic connections in the same circuit of neurons were strengthened and became more efficient, resulting in an increased release of neurotransmitters, and the slug became able to avoid the negative stimuli that had initially caused the reflex.

These experiments, combined with his later research on mice, determined that biochemical changes in synaptic function form different types of memory. Kandel showed that weak stimuli give rise to certain

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chemical changes in synapses which are the basis for short-term memory. In contrast, stronger stimuli, or repeated exposure to the stimulus in question, cause an increase in the number of synapses along with different synaptic changes requiring protein synthesis that produced an alteration in the shape of synapses found on neuronal membranes. Kandel found that these new synaptic shapes increased the sensitivity of synapses to further stimulation and improved synaptic function, which resulted in demonstrable long-term memory.

Kandel and his colleagues believed that the nervous systems of organisms – whether they have 20 000 neurons or 100 billion neurons – share similar mechanisms for learning, and that the essence of our memory lies in biochemical and physiological changes to neurons within the brain.

In 2000, Kandel was awarded the Nobel Prize in Medicine for his work in discovering key molecular mechanisms of learning and memory.

The function of the hippocampus

The **hippocampus**, a structure within the interior of the brain wrapped around the thalamus and extending into the temporal lobes, plays a major role in memory, learning, and recognition. Research suggests that the hippocampus is critical to the formation of memories, playing a part in deciding if information received by the senses is worth remembering, then mapping and organising memories before directing them to other sections of the brain, perhaps to several sections at once. The general role of the hippocampus in memory consolidation appears to be to provide a cross-referencing system that links and, when necessary for memory retrieval, draws together all the different aspects of a memory from around the brain.

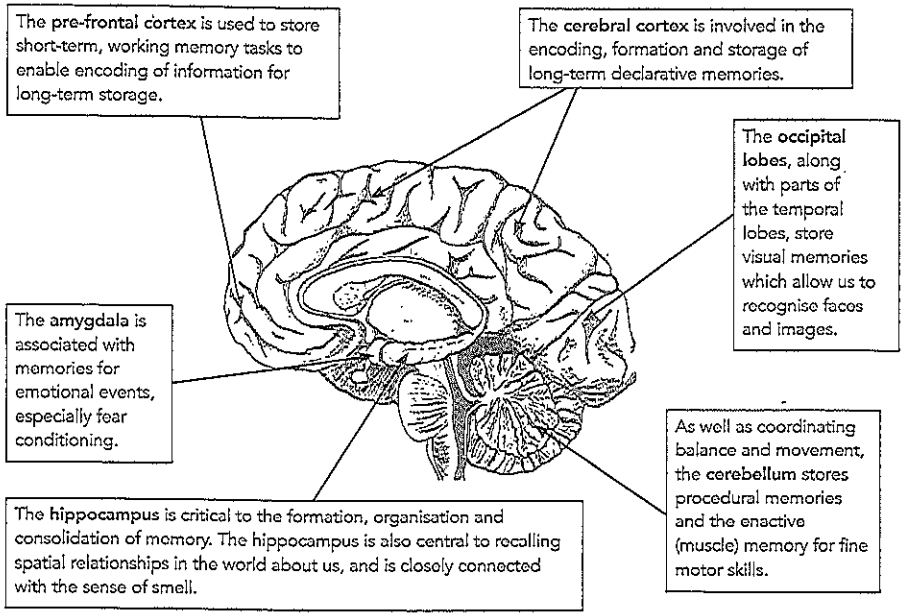
The hippocampus is central to recalling spatial relationships in the world about us, with damage resulting in disorientation and an impaired ability to navigate our way in familiar settings.

The hippocampus is also closely connected with the sense of smell, helping to process signals from the olfactory bulb. This may account for the power of certain odours to evoke vivid memories and strong emotions.

People who have suffered extensive damage to both sides of the hippocampus can often remember events that occurred before the damage, but cannot form new long-term memories of events that occur after the damage (anterograde amnesia). This finding was primarily derived from research into the case of a patient known as H.M. In an attempt to relieve epileptic seizures, he underwent surgery which destroyed his hippocampus, resulting in an inability to consciously remember events that occurred after his surgery or for several years before it (Scoville and Milner, 1957). These results have been observed in studies with other patients with similar levels of hippocampal damage and amnesia caused by accident or disease.

Patients with unilateral (one-sided) lesions of the hippocampus have specific deficits. If damage occurs to the hippocampus in the right hemisphere, there are problems with tactile and visual image learning, facial recognition, and spatial memory and association. If the left hippocampus is damaged, there will be difficulties with the recall of word lists and digit span. It would therefore appear that the left hippocampus is important for verbal memory whereas the right is important for spatial and visual memory.

Key brain structures involved in memory



Consolidation theory

Just as concrete takes a period of time to set, harden and become permanent, so does the 'setting' of information into long-term memory. **Consolidation theory** proposes that, in order for new information to be transferred effectively from short-term to long-term memory, there needs to be a time period during which these memories are able to fortify or stabilise without being disrupted. During this time, physical changes to the neurons occur to enable permanent storage of the new information.

> Consolidation is when memories become **solid** (firm and fixed).

If this consolidation period is disrupted, either by an accident or interference, the memory may be altered or completely lost.

Consolidation takes at least thirty minutes on average. Like concrete, once the memory is consolidated it is relatively permanent.

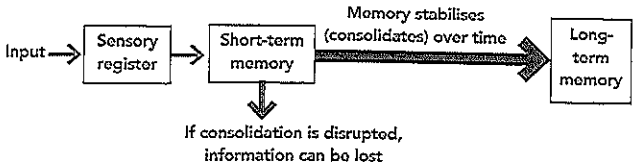
> The process of consolidation can be likened to making jelly. Initially, if you knock the bowl, then material can be spilled (displaced and lost as a result). Whereas, given time under the right conditions, it will set and become firm.

Memory decline over the lifespan

Memory decline is **not** an automatic part of the normal ageing process. Despite stereotypes portraying older people as absent-minded, forgetful or senile, many elderly people retain alert minds, and there have been many reported cases of elderly individuals obtaining higher degrees at university.

Research has demonstrated an age-related decline in the ability to recall newly learned material such as word lists, number strings, nonsense syllables, and newly introduced individuals. **Recognition**, on the other hand,

Processing information into long-term memory – consolidation



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appears not to be greatly affected. This difference may be due to **cognitive slowing**, whereby aged subjects demonstrate a slowing down of neural processing, taking longer to encode information for storage and consolidate material into their long-term memory.

Episodic memory within older people may be affected, tending to show some decline from ages 30–50 years. These memories are less well-learned, and are more context-dependent and state-dependent in nature. Well-learned **semantic memories** are more easily accessed and less vulnerable to ageing. **Procedural memory** also appears to stay the same as when the person was younger, but the performance of tasks could be limited by physical factors.

Some factors which may influence the rate that an individual may forget previously learned information are:

- how meaningful an individual makes the material to be remembered. The more meaningful information is, the less rapidly it is forgotten
- how well the original material was initially learned. The stronger the original learning, the less likely material will be forgotten. This is the case regardless of the difficulty of the material to be retained, and the cognitive ability of the learner.

Elderly individuals may also exhibit memory decline due to a loss of confidence in their own ability to learn or retrieve information, creating a self-fulfilling prophecy, or a lack of motivation to perform tests of memory, especially if the methodology is based on the use of meaningless/nonsense information. These potentially confounding variables should be considered when evaluating research on memory decline in the elderly.

Individuals who use their memory and remain mentally active tend to suffer less memory loss than those who do not. This is consistent with the adage: 'Use it, or lose it!'

Organic forms of forgetting

No one, specific brain area handles all aspects of memory and, like most cognitive activities, the cooperation of many brain areas is required for normal functioning. Organic forms of forgetting are those where memory loss occurs due to physiological/biological factors that cause damage to the brain and thereby interfere with its proper functioning.

Amnesia

Amnesia is the loss of the ability to memorise information and/or to recall information stored in memory, and could be due to physical and/or psychological factors.

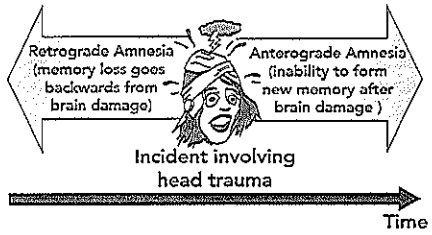
Organic amnesia refers to the partial or complete loss of memory due to physiological factors. This memory loss can be either temporary or permanent in nature. Some of the factors that may cause organic amnesia include brain damage from strokes, brain tumours, neurosurgery, alcoholism (leading to Korsakoff's syndrome), severe malnutrition, head injuries, car accidents, anoxia (oxygen deprivation) and neurodegenerative diseases (such as dementia, including Alzheimer's disease, and the later stages of AIDS).

An individual suffering from **anterograde amnesia** would be unable to remember events which occurred after they sustained damage to their brain. Their memory for events occurring before the brain damage is still intact. The hippocampus, located in the forebrain, may be affected. Short-term memory is affected, leading to an inability to encode and learn new information, thereby impairing the transfer of novel memories to form long-term memory. Patients with Korsakoff's syndrome or those in the early stages of Alzheimer's disease display anterograde amnesia.

Retrograde amnesia, on the other hand, occurs when damage sustained to the brain affects memories for events that happened *before* an individual sustained damage to their brain. This memory loss may affect the recall of memories which are moments, days, weeks, months or even years old. Areas storing long-term memories are affected, rendering the individual unable to access information learned prior to the accident/trauma. Most recent events are the most likely to be lost, and the amount of loss can be from minutes to years depending on the severity of damage to the brain.

A typical pattern of recovery of memory after retrograde amnesia could be rapid initially, followed by slower (or sporadic) recovery. There is a gradual shortening of the period of memory loss, usually remembering the most distant events first. Different aspects of memory recover at different rates, for example episodic memory is faster than semantic memory, with the rate of recovery increasing as newly rediscovered memories cue recall of other items within the semantic network. Events immediately prior to the accident are likely to permanently forgotten, especially due to disruption of consolidation.

A brief period of retrograde amnesia is always caused by shock therapy (ECT), with patients unable to remember the treatment or the events directly preceding it. Longer-term retrograde amnesia can occur due to brain tumours, strokes or diseases (especially in the later stages of Alzheimer's disease).



Retro- indicates backward movement. Therefore, the **effect** on memory for **retrograde** amnesia goes **back** in time. Consequently, the **effect** on memory for **anterograde** amnesia is **forward** in time/after the head trauma. Anterograde amnesia is after the damage.

Dementia

Dementia is a broad term used to describe memory loss along with changes to thinking ability, social skills and emotional responses. It is caused by a variety of disease processes that all gradually destroy cellular structure and chemistry in several areas of the brain leading to progressive and eventually severe decline in mental function. Memory impairment is a necessary feature for the diagnosis in addition to change in one of the following areas: language, decision-making ability, judgement, attention, visual-spatial perception, emotional behaviour or personality, and cognitive skills.

When someone has dementia, sections of the brain gradually become damaged and stop working properly, affecting what that person does and says. This means that a person with dementia may:

- find it increasingly harder to remember people and events, especially recent events
- find it increasingly difficult to think about and process information, especially learning new things
- misplace things
- be unable to do everyday tasks such as eating, dressing, driving, or taking care of themselves
- display strange or uncharacteristic behaviours
- become easily upset or confused about time and place
- be unusually aggressive or suspicious
- have trouble speaking clearly, jumbling and confusing their words
- have problems understanding what others are saying
- gradually lose their ability to communicate through written language.

There are individual differences in the speed of progression of dementia, with each person experiencing dementia in their own unique way.

There are many causes of dementia, with **Alzheimer's disease** the most common cause (approximately 55 per cent) of dementia in older persons.

The second most common type of dementia (approximately 20 per cent) is **vascular dementia** (or multi-infarct dementia), which is resulting from reduced blood flow to the brain's nerve cells caused by a series of strokes or changes in the blood supply to the brain. If the oxygen supply to the brain fails, brain cells are likely to die as a result. Signs of this form of dementia may appear suddenly, following a major stroke, or over time through a series of small strokes. If the strokes stop, the patient can get better or stay the same for a long time, but if the strokes continue, their condition will get worse.

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Dementia with Lewy bodies (approximately 15 per cent) gets its name from tiny spherical structures that develop inside nerve cells. Their presence in the brain leads to the degeneration of brain tissue. Memory, concentration and language skills are affected.

In fronto-temporal dementia (approximately 5 per cent of dementia cases, including Pick's disease), damage is usually focused in the front part of the brain, initially affecting personality and behaviour more than memory.

Other causes of dementia include Creutzfeldt–Jakob disease (CJD), Korsakoff's syndrome, and HIV/AIDS. People with multiple sclerosis (MS), motor neurone disease, Parkinson's disease and Huntington's disease can also be at an increased risk of developing dementia.

Dementia affects all groups in society and is not linked with social class, gender, ethnic group or geographical location. The risk of developing dementia is, however, strongly associated with ageing, although inheritable early-onset dementia does occur very rarely in people under 65 years. Approximately 5–8 per cent of all people over the age of 65 have some form of dementia, and population studies show that the prevalence (number of cases) roughly doubles every five years above that age. It is estimated that as many as half of people in their eighties suffer from dementia. 'Senile dementia' and 'senility' are outdated terms that were once used to refer to any form of dementia that occurred in older people.

At the moment there is no cure available that can alter or reverse the underlying degeneration of brain cells in dementia patients, although several of the problems associated with dementia such as restlessness and depression can be treated.

Alzheimer's disease

First described by Dr Alois Alzheimer in 1906, Alzheimer's disease is an irreversible, progressive degeneration of nerve cells in the brain resulting in shrinkage of the brain substance, particularly in the hippocampus and related areas of the mid-brain, eventually leading to the death of the patient.

Alzheimer's disease is the single most common cause of dementia, accounting for 50–60 per cent of all cases, with deterioration of memory being the most widely recognised feature of the disease. The early stages of the disease are characterised by problems with short-term memory, including forgetfulness and difficulty in forming new memories. Episodic memory is more noticeably affected, although there may also be problems with recent semantic memory as well. As the disease spreads through the cerebral cortex, the individual gradually forgets how to do routine tasks that they have been doing throughout their lives, from simple skills to the recognition of family members. Other features of the disorder include the patient becoming confused and disoriented about time and place, a decline in concentration and numerical abilities, an increase in frustration, unpredictable mood swings and emotional outbursts, changes in personality and language impairment. Progression of the disease leads to the death of more nerve cells and subsequent behavioural changes, such as wandering and agitation. In the final stages, patients lose bowel and bladder control, and eventually need constant care. This stage of complete dependency may last for years before the patient dies. The average length of time from diagnosis to death is 4–8 years, although it can take 20 years or more for the disease to run its course.

Effects of Alzheimer's disease on the physiology of the brain include:

- senile plaques (abnormal clusters of dead and dying nerve cells, the products of which have accumulated around sticky molecules of beta-amyloid protein. In Alzheimer's, these have been transformed into a form which is toxic to the brain)
- neurofibrillary tangles (insoluble, twisted structures caused by the build-up of protein and plaques within nerve cells that clog up the cell)
- atrophy (wasting away) of brain tissue (especially deterioration of hippocampus and eventual general brain shrinkage from cell death. At death, an Alzheimer's brain may have lost up to 50 per cent of its weight.)
- destruction of neurons involved in production of some neurotransmitters, especially acetylcholine, which is necessary for cognitive functioning.

The cause of Alzheimer's disease is unknown, but it probably results from a variety of genetic and environmental causes. While it is most common in the elderly, with the prevalence of Alzheimer's doubling every five years beyond age 65 and possibly affecting about one in four people over the age of 85, it is not a natural result of ageing, and early onset cases have been reported for patients in their thirties and forties.

There is currently no cure for Alzheimer's disease. The only available treatments are drugs that boost the efficiency of damaged neurons or ease some of the secondary symptoms of the disease, such as depression. New drugs are being developed which are aimed at inhibiting the production of toxic effects of the beta-amyloid protein plaques. Research evidence suggests that an active intellectual life, including regular social interaction, reduces the risk of Alzheimer's disease, or at least hinders its onset.

Comparison of models for explaining human memory

It is generally accepted that memory involves an active, information-processing system that receives, organises, stores and recovers information.

Levels of processing (Craik and Lockhart)

While people emphasise retention of information as being the role of memory, there are in fact three key processes that are required.

Encoding, storage and retrieval

New information is encoded by converting it into a useable, meaningful form or code for input into the information processing system, thereby preparing it for integration and storage in LTM. Various methods for encoding information include making it meaningful, association with existing memories, using visual imagery, and attaching personal references or emotions.

Craik and Lockhart (1972) believed that it is the depth of processing which determines whether information is stored over a long rather than a short period. They defined depth in terms of a continuum based on the meaningfulness extracted from the stimulus rather than in terms of the number of analyses performed upon it.

According to Craik and Lockhart (1972), the three levels (types) of encoding are:

1 **Structural (surface)**
   - shallow processing on a superficial, perceptual level, focusing on the physical attributes or appearance of the information; e.g. how the letters look or the typeface of a word
   - items may be easily forgotten
2 **Acoustic (phonological, phonemic)**
   - retention of stimuli according to what it sounds like
   - moderate level of processing
3 **Semantic (meaning)**
   - attaching meaningful associations in order to understand the items to be remembered
   - deepest level of processing.

In addition to the depth of processing while encoding, Craik and Lockhart identified elaboration of processing and distinctiveness of processing as key determinants in the formation of long-term memory.

Storage entails the retention of information in memory over time. However, storage of information does not guarantee the individual's ability to retrieve it.

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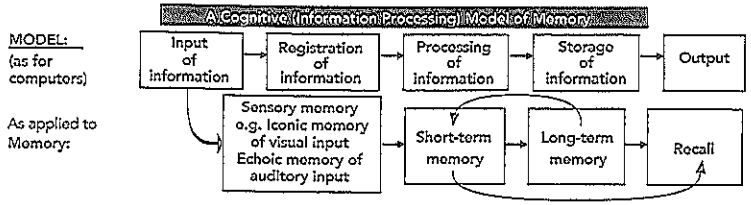
Retrieval involves recovering or accessing previously encoded information that has been stored in our long-term memory so that it can be used. This process depends on the manner of encoding and occurs best when retrieval cues match those present during encoding.

Information processing models of human memory

Information processing theories focus on people's ability to attend to their environment, encode information, store facts and retrieve knowledge. These theories assume that human information processing is analogous to computer processing with input of information through the senses and processing occurring in stages that intervene between receiving a stimulus and producing a response. This approach focuses on memory according to the type of processing, rather than the location of the information.

A Cognitive (Information Processing) Model of Memory

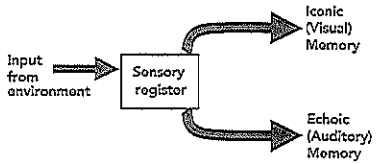


Atkinson-Shiffrin's multi-store model of memory

According to the information-processing model of memory, there are three separate levels of memory that interact with one another to enable encoding, storage and retrieval of information. These levels are sensory memory, short-term memory and long-term memory.

Sensory memory

Sensory memory refers to items detected by the sensory receptors which are retained temporarily in the sensory registers. These sensory registers have a large capacity for unprocessed information, but are only able to momentarily preserve extremely accurate images ('traces') of sensory information; just long enough for relevant details to be attended to and transferred to short-term memory. The function of sensory memory is to briefly save our sensory impressions so that a slight overlap occurs, thereby enabling us to perceive our environment in an uninterrupted fashion rather than as a series of disjointed images and sounds.



The two types of sensory memory that have been most extensively explored are iconic (visual) memory and echoic (auditory) memory (Neisser, 1967).

Iconic (visual) memory

Iconic memory receives visual sensory information from the eyes and holds a brief visual image of what has just been perceived. The capacity is very large, limited only by the individual's field of vision. The duration of visual images in iconic memory is approximately 0.3 seconds, which allows 'smooth' perception rather than the blurring of moving objects.

> Iconic → begins with I → rhymes with 'eye' = Visual
> This form of memory can be remembered by recalling that icons are pictorial in nature, either as graphics for computers or as artwork (especially religious paintings).

Echoic (auditory) memory

Echoic memory is the sensory memory for audition (hearing), i.e. for sounds that have just been perceived. The capacity is very large, limited only by the individual's range of hearing. The duration of sounds in echoic memory is approximately 3–4 seconds; a briefer interval would not allow enough time to attend and process sensory information, e.g. speech. For example, someone talks to you while you are watching TV and you respond to the sound of their voice by saying 'What?' After a second, you suddenly realise what they said because of processing the echoic memory and can then respond.

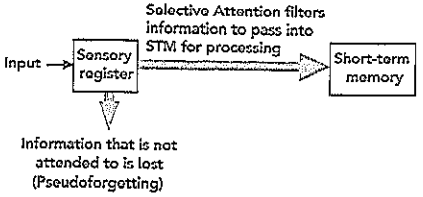
> Echoic ←→ Ear → Hearing/Auditory
> This form of memory can be remembered by recalling that echoes involve sound bouncing back from objects so that we can hear them again.

	Iconic (visual) memory	Echoic (auditory) memory
[illegible]	essentially that of the sensory system involved – very large (Sperling)	
[illegible]	approximately 0.3 seconds	approximately 3–4 seconds
[illegible]	none additional beyond raw perceptual processing	

Loss from sensory memory can be due to both interference and decay. Loss of information is faster when one stimulus is quickly followed by another, which pushes it out of sensory memory (Sperling, 1960). Information that is not quickly passed to short-term memory is gone forever.

As an enormous amount of sensory information is constantly entering our sensory systems, we must focus our attention on a stimulus or mental event, thereby shutting out competing stimuli, in order to select what information will be processed within our short-term memory.

Attention



Short-term memory (STM)

Short-term memory (STM) allows an individual to manipulate information contained in sensory or long-term memory. It has a limited capacity, and information is retained for a duration of approximately twenty seconds. Because of this, short-term memory is very susceptible to interruption or interference.

Capacity of short-term memory

The digit-span test is a measure of attention and short-term memory which tests the recall of a series of digits. Findings from such tests show that short-term memory has an average capacity of seven plus or minus two units of information (Miller, 1956).

> Short-Term memory holds Seven ± Two items.

Effect of chunking

An individual may increase the storage capacity of STM using chunking, the grouping of single units of information into higher order units. This will allow an individual to remember seven plus or minus two 'chunks' or slabs of information, as opposed to seven plus or minus two individual units of information. For example, an individual may group the numbers 2, 0, 1, 1 into the year/number 2011. Chunking can also involve organising items into familiar, manageable units, such as the use of acronyms, e.g. BOLTSS – Borders, Orientation, Legend, Title, Scale, Source.

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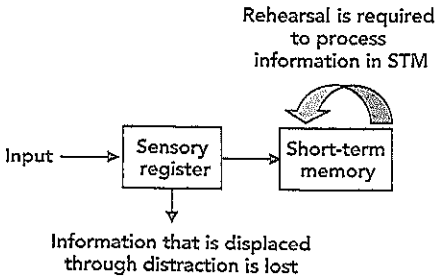
	Short-term memory
Capacity	Limited to approximately 7 ± 2 bits of information (Miller, 1956); this can be expanded by 'chunking' information into larger units
Duration	Approximately 18–20 seconds (Peterson et al, 1959)
Processing	To hold information in STM, it is often encoded verbally; however, other strategies such as visualisation may be used, making it possible to 'rehearse' the information.

Rehearsal

Rehearsal maintains information in STM by preventing it from being lost or displaced by other material. The longer information is in STM the greater the probability that it will be transferred into storage within long-term memory. The more frequent information is rehearsed, the better it is retained over time.



Maintenance rehearsal relies on the conscious recitation of information in a rote fashion, so that it can be kept in short-term memory for longer than the usual maximum duration of approximately twenty seconds. For example, repeating information over and over in an individual's head. Maintenance rehearsal is easily affected by distraction which can displace information from our STM.

In contrast, elaborative rehearsal involves the process of expanding upon new information by adding to it or linking it to what an individual knows, thereby making it more meaningful (for encoding and retrieval).

This may involve the analysis of semantic, sensory or physical attributes of the item to be remembered, which is then associated with items already stored in long-term memory or with other new information to aid encoding. The deeper the information is processed, the better it will be remembered.

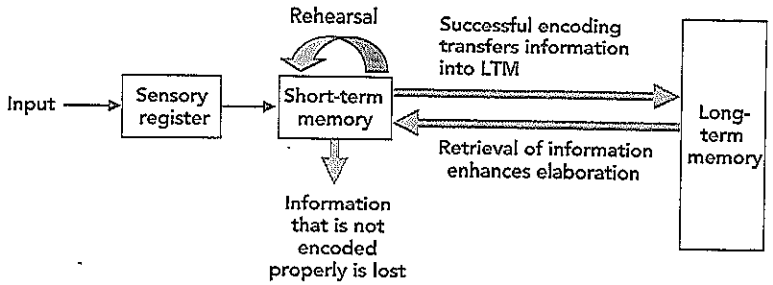
When you are asked to **elaborate** about something, you need to **give/add** more information to make what you are saying more **meaningful**. The same is true with this form of rehearsal.

Long-term memory (LTM)

	Long-term memory
Capacity	Virtually unlimited
Duration	Up to a lifetime – relatively permanent
Processing	Information is organised according to meaning and is associatively linked

The following sentence could help to remember the types of LTM:
'Long-term memory proceeds to declare semantic episodes.'
(Note: this sentence is not meant to make sense or be a definition, merely act as a trigger for key words/terms.)
Conversely, the terms and their meanings are pretty clear if you think about the words themselves:
Procedural – procedures involve the way to **do** things → **actions**
Declarative – to declare something is to provide **information** in words
Episodic – episodes are series of **events** (alternatively, remember this term also refers to sequential TV shows)
Semantic – semantics involves the meaning of words → **facts**

Processing information into long-term memory – encoding



Long-term memory (LTM)

Long-term memory (LTM)

LTM is a relatively permanent memory system which theoretically has an infinite capacity for storing information for an extensive period of time.

Long-term memory stores all the information which we do not need right now. Such information is not immediately active, and needs to be retrieved back into our short-term memory when the time comes to use it.

Long-term memory can be categorised into **four types.**

Procedural memory is a type of long-term memory involving thought processes and skills about how to perform a task which enable an individual to carry out a course of action. For example, riding a bike or tying an individual's shoelaces.

Declarative memory is a type of long-term memory of specific facts or events which can be brought consciously to mind and usually be put into words in order to communicate to others. Declarative memory may be divided into two sub-categories, episodic memory and semantic memory.

Episodic memory is a form of declarative memory which contains autobiographical information about personal events and experiences in an individual's life and the contexts in which they occurred. An example may be recalling the date, place and what happened at a twelfth birthday party.

Semantic memory is a type of declarative memory which involves specialised knowledge of factual information about the world. This includes general knowledge, academic knowledge of the variety learned at school, as well as the meaning of words. Examples would be identifying the elements in the periodic table or the knowledge that a whale is a mammal.

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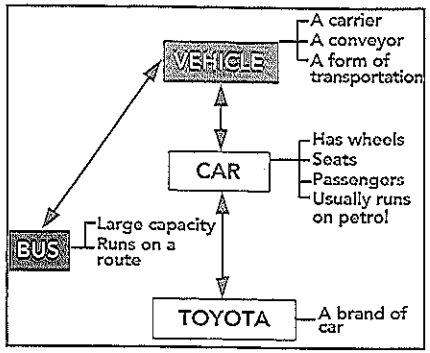
Organisation of information in LTM – semantic network theory

The semantic network theory proposes that long-term memory is organised systematically into hierarchical networks of concepts (nodes), arranged as inter-related overlapping categories and sub-categories. Information within the nodes is interconnected via meaningful links. Rather than retrieval being an exhaustive, sequential process, relevant memories activate nodes for other related memories. The more nodes activated, the more chance the correct information will be retrieved.

Material that is organised well is therefore easier to learn and recall. A shorter link between two concepts in a semantic network indicates a strong association between concepts; while a longer link between two concepts illustrates a more distant association.

The linkages between concepts may be based on categories, rules, images, symbols, or formal or personal meaning.

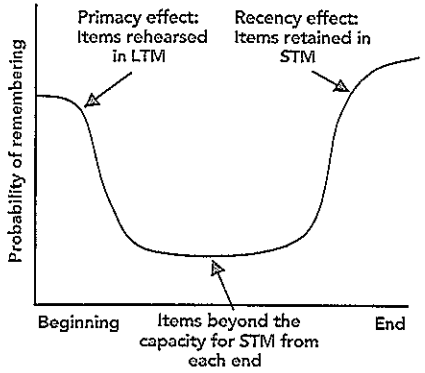
The following semantic network is a simplified example illustrating a hierarchical arrangement of interrelated networks of categories and sub-categories.



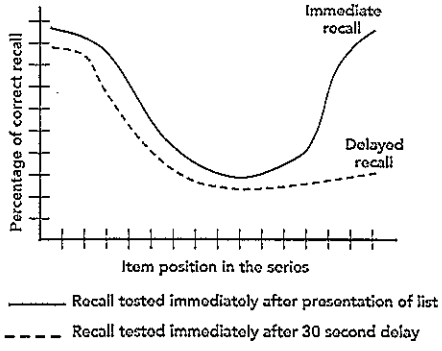
Serial position effect

To explore the serial position effect, subjects are required to recall items from a serial list, which is a series/list of items such as numbers, nonsense syllables or words.

The serial position effect displays the tendency for recall of items in a serial list as being superior for items at the beginning of the list due to the primacy effect, and if tested immediately after presentation of the list, for seven plus or minus two items at the end of the list due to the recency effect.



The primacy effect, the tendency to remember initial information, would be due to the fact that items have been rehearsed and are more likely to have been stored in long-term memory, whereas the recency effect, the tendency to recall later information, would be due to the fact that items are still in short-term memory. However, studies by Glanzer and Cunitz (1966) have shown that if recall is delayed for 30 seconds with no rehearsal after the presentation of the list, then the recency effect is vastly diminished, if it is evident at all. The same result is also caused by serial recall.



Working memory (Baddeley and Hitch)

Baddeley and Hitch (1974) viewed the modal model of memory as portraying short-term memory as a memory system with a limited capacity involved in the retention of information for brief periods or temporary use, emphasising container aspects at the expense of processing aspects.

Rather than short-term memory being a single inflexible store, they proposed that working memory was made up of several subsystems, each having a specialised function in processing small amounts of information, such as performing mental arithmetic, dialling a telephone number and remembering a brief list of items. Their model referred to short-term memory as active memory, as it is used in the analysis and interpretation of information during decision making, problem solving and the writing and comprehension of language. They supported their model with empirical evidence whereby participants were able to carry out more than one task simultaneously where both tasks involved short-term memory functions that reached the full capacity of STM.

According to Baddeley (1986), working memory is an active system that provides temporary storage for the manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning, reasoning and problem solving. This information can either be derived from processing of sensory input, retrieved from long-term memory or recently generated by ongoing operations. Working memory acts as a workbench where all the resources needed for a particular task are placed.

Initially, working memory was divided into the three sub-components. The most important aspect of working memory is the central executive, which is described as very active and responsible for the selection, initiation and termination of processing routines (e.g. encoding, storage and retrieval). The central executive is used for storing information about the goals active at the moment, prioritising what items require attention at that time while planning towards resolving the current task. It coordinates the input from the other components of working memory, along with accessing information from long-term memory, to retrieve information required to achieve the result or to assigning meaning to assist in elaboration to commit the information to long-term memory. Many of the inputs to this system are from cognitive processes rather than perceptual mechanisms.

> To remember the essentials for this concept, think of the meaning for each word in the term: **central**, being in the middle (of the flow of information) and **executive** as being 'the Boss' telling everyone what to do.

The visuo-spatial sketchpad is responsible for the temporary storage and manipulation of visual and spatial information, dealing with what information looks like and how it is laid out. It can be used, for example, for constructing and manipulating visual images, and for the representation of mental maps. Logie (1995) proposed that the sketchpad can be further broken down into the visual cache, which deals with information about form, shape, colour, and texture, and the inner scribe, which is a spatial subsystem dealing with location, planning of spatial movements, or the speed of objects in space. The latter also rehearses information in the visual cache and transfers information to the central executive.

> To remember the essentials for this concept, split the keyword: **visuo** = visual and **spatial** = within 3D space. Also, a **sketchpad** is where we draft and try to work out things in a visual manner.

The phonological (or articulatory rehearsal) loop, responsible for storing speech-based information, comprises two parts. The first component is a short-term *phonological memory store*, acting as an 'inner ear', which can hold auditory memory traces of acoustic or speech-based material. Material in this short-term store is subject to rapid decay, lasting about 1.5 to 2 seconds, unless it is maintained through the use of the second sub-component, articulatory sub-

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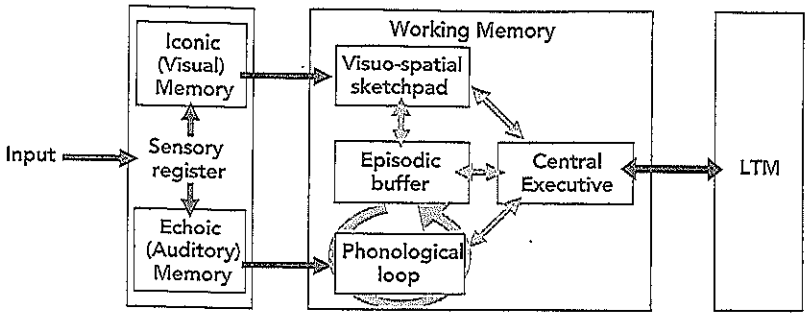
The phonological loop



vocal rehearsal that acts as an 'inner voice', reviving the memory traces by repeating the series of words (or other speech elements) on a loop to prevent them from decaying. Prevention of articulatory rehearsal results in very rapid forgetting.

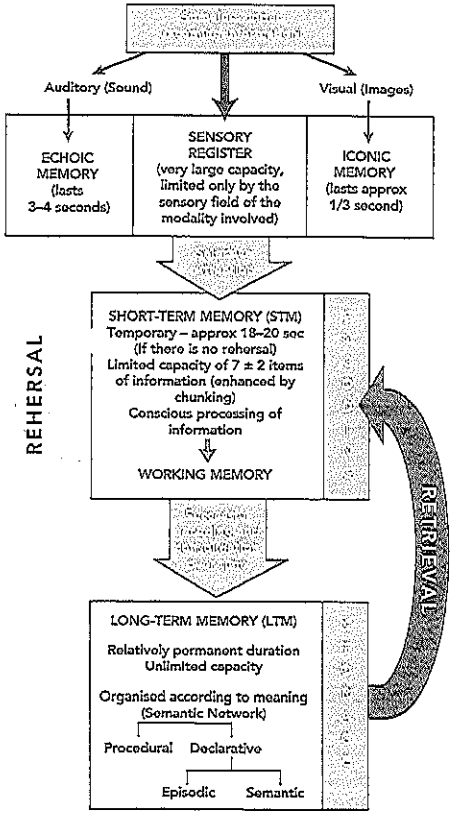
Visually presented language can be transformed into phonological code by silent articulation and thereby be encoded into the phonological store. This transformation is facilitated by the articulatory control process.

> **Phono** pertains to sound.
> **Articulate** means 'to speak'.

The storage capacity within working memory is due to the phonological loop or visuo-spatial sketchpad, whereas the processing of complex information is the function of the central executive.

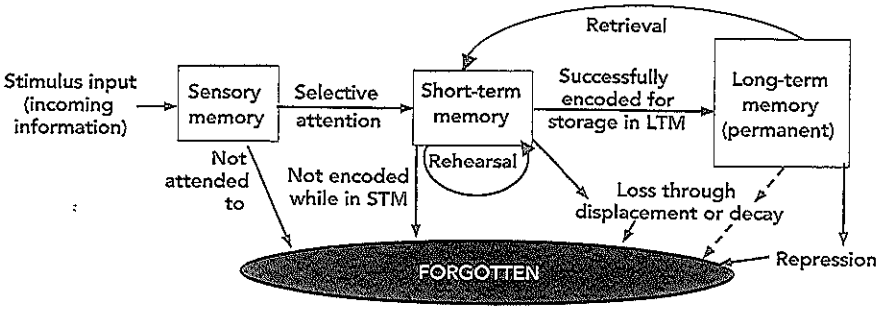
As the original model did not account for general storage that could combine several kinds of information, Baddeley extended the model in 2000 by adding a fourth component, the episodic buffer. This is a third slave system with limited capacity that provides temporary storage of representations that incorporate phonological, visual, and spatial information, and possibly data not covered by the other slave systems (e.g. semantic information, music). It is assumed that this system binds information to form integrated, meaningful units with time sequencing (or chronological ordering), such as the memory of a story or a movie scene.

The main motivation for introducing this component was the observation that some (in particular, highly intelligent) patients with amnesia, who presumably have no ability to encode new information in long-term memory, but who nevertheless have good short-term recall of stories, recalling much more information than could be held in the phonological loop.



Psychological theories of forgetting

Forgetting within the Modal Model of Memory



Information processing theories focus on people's ability to store and retrieve knowledge.

Forgetting, however, involves the loss of information or the inability to access previously encoded information within memory. Forgetting can be seen as beneficial in certain circumstances because it rids us of outdated and useless information, clearing the way for the storage of relevant material. Forgetting can occur at any stage of memory. Attention is selective, as we cannot process everything within our environment. As a result, it may seem as if we have forgotten material, however, the information never actually entered the memory system.

Pseudoforgetting involves the forgetting of meaningful material due to the fact that it was never properly stored into long-term memory in the first instance.

Pseudoforgetting can be illustrated by the following scenario: *Sally was reading her favourite novel but, after reading two pages, she realised that she had 'forgotten' what she had read as she was thinking about her impending English test.* The reason that she had 'forgotten what she had read' was not due to memory loss, but the fact that the paragraphs she was reading were never really stored in long-term memory in the first place. This was because Sally was not attending to the words, but thinking about her English test.

Information being held in short-term memory can be pushed out by newly arriving information. Displacement is most likely to occur when limit of the capacity for short-term memory has been reached (about seven units of information). This accounts for the drop in ability to recall middle items in the serial position effect.

Encoding failure means that information fails to enter long-term memory and, as a result, is forgotten. Further to this, if consolidation is disrupted, information can be lost as long-term memory traces are not able to stabilise over time.

Retrieval failure theory

Retrieval failure theory, also referred to as cue-dependent forgetting, occurs when an individual is unable to access information from long-term memory, even when they are certain they know the information. Information that cannot be retrieved appears to be lost, but forgetting of this type is not permanent as information can be retrieved with the correct 'cues'.

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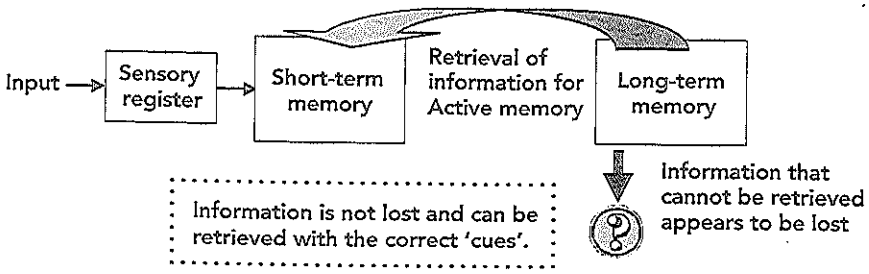
Retrieval Failure



Trace-dependent theories of forgetting, on the other hand, account for memory loss occurring as a result of physical alterations to memory traces located mainly in the central nervous system.

Decay theory, interference theory and motivated forgetting theory are all trace-dependent.

Decay theory

According to **decay theory**, memory traces that store data within the brain fade or disintegrate over time unless they are reactivated by occasional use. The underlying assumption is that memories are stored within the brain as a physical (biological/organic) or bio-chemical change. This memory trace deteriorates or weakens over time if it is not kept alive through repetition, rehearsal, or reactivation. This reversal/dissolution of the change made when the memory was formed (consolidated) results in an individual forgetting the stored information as it gradually erodes from disuse.

> While it may be a 'gross' analogy, the image of a rotting corpse gives a clear impression of the effect of decay. If neglected and not kept alive, the memory will break down, just like the corpse, until little if anything is left.

Decay theory, however, fails to explain why older people, particularly those suffering from dementia, cannot remember recent events, but have vivid memories of events long past. Decay theory also does not explain why some unused memories fade, whereas other dormant memories can be recovered, given the right cues.

'Tip-of-the-tongue' phenomenon

The **'tip-of-the-tongue' phenomenon** occurs when an individual is confident that they know something, but are not quite able to access it from memory at that particular point in time. The individual may be able to describe characteristics of the item, (such as the first letter, length, what it looks like, etc.), but not the actual word/term/name itself.

As the apparently lost information can, over time, eventually be retrieved from long-term memory, it would appear that other factors (retrieval failure) may be responsible for memory loss rather than decay of memory traces over time.

This phenomenon suggests that memories are stored in the brain in a complex manner involving a number of locations. For the complete memory to be retrieved, each location must be accessed. It may be that, when retrieval fails, the right cue was unavailable and the person only accesses one or two of the locations bringing only part of the whole memory back out of storage.

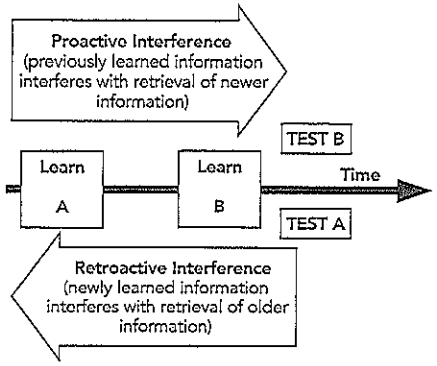
Interference theory

According to the **interference theory**, some material may disrupt the retrieval of other information, such that different items stored in memory get confused with what an individual is trying to remember. Forgetting, therefore, results from competing associations between the different concepts stored in long-term memory. This is more likely to occur if the interfering memories are similar in nature to the information an individual is trying to remember, whereas consistency between old and new information can actually promote retention. The likelihood of interference occurring is also affected by the strength of the original encoding and the number of alternative paths within the semantic network.

Proactive interference occurs when previously stored information interferes with the ability to remember similar, more recently learned material.

On the other hand, **retroactive interference** occurs when newly learned information interferes with the ability to remember similar material stored previously.

Interference may be due to overwriting, where new memory traces affect storage by damaging or removing old memory traces. Another explanation focuses on response competition, where new traces added to memory make it harder to find and retrieve older memory traces. Old memory traces are still stored, but they are inaccessible at that time.



> Both terms for interference end in **-active**. Remember that learning is involved in interference and that learning in this context is an **active** process.
> **Pro** means 'for' or 'to put forward', and **active** often refers to going forward, so both parts of the term **proactive** indicate that the effect goes **forward** in time.
> **Retro** comes from the Latin word for 'backwards'. Associate the term with retro music, fashion or with retrorockets. Therefore, the effect on memory for **retrograde** interference goes **backwards** in time.
> Note: be careful not to confuse retroactive interference with retrograde amnesia!

It would be inadvisable for a student who is about to sit an examination to learn two subjects in succession which are similar in nature, as interference may occur.

Interference, whether it is retroactive or proactive in nature, is minimised when information to be learned following one another is dissimilar in nature. Therefore, if an individual studying for the Psychology examination wanted to prevent interference from causing them to forget what they had just learned, they should revise unrelated subjects such as Specialist Mathematics or Physics, either before or after their studies in Psychology. Furthermore, if practical, the student could timetable a rest break before and after learning Psychology to minimise interference from other similar subject matter.

Motivated forgetting (Freud)

The **motivated forgetting theory** is based on Freud's observation that individuals employ the mental defence mechanism of **repression** to unconsciously block out painful or unpleasant memories from ordinary waking consciousness. Also known as psychogenic amnesia, this phenomenon involves the partial or complete loss of memory (due to non-organic causes) to protect the individual from the long-term effects of threatening information or traumatic experiences. These memories still exist, however, and later events may bring them back to the surface, or else they may emerge in dreams or nightmares.

Repressed memories, such as being in a car accident as a young child, may be retrieved back into an individual's ordinary waking consciousness either through counselling, in dreams or when relevant topics are raised which arouse/trigger emotions associated with the unpleasant experience.

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Suppression, on the other hand, is the process by which a person consciously tries to forget unacceptable or painful information by pushing it out of their consciousness.

The theory of repression has been criticised because of its lack of support from empirical evidence. Repression cannot, however, be the subject of experimentation or laboratory testing because of the many ethical issues involved, and so researchers have to rely on anecdotal evidence from case studies to explore this theory.

Further to this, in trying to access repressed memories, it is possible for pseudomemories to be created. Pseudomemories are false memories that may result when accurate information is combined with fantasies and possibly suggested thoughts given during therapy (especially hypnosis). Recent research has demonstrated that certain forms of therapy can lead to the formation of such memories, especially in cases of suspected child sexual abuse where over-zealous therapists have inadvertently planted pseudomemories in their (now adult) client's heads because of therapeutic techniques involving imagery, suggestive questioning or repetition.

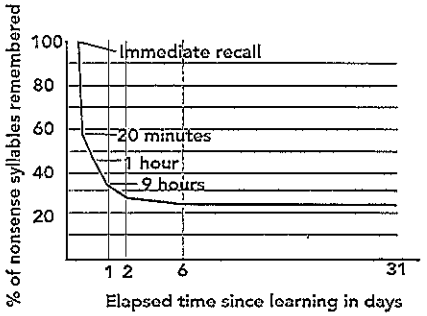
Also, some unpleasant memories, such as car accidents or for victims of assault, may be lost due to interruption to consolidation rather than be due to repression.

Manipulation and enhancement of memory

The forgetting curve (Ebbinghaus)

Hermann Ebbinghaus (1850–1909) employed nonsense syllables in his studies of memory. **Nonsense syllables**, consisting of a vowel in between two consonants such as 'bep', were chosen because they are meaningless and would therefore be unaffected by associations with words already stored in memory.

Ebbinghaus claimed that when an individual memorises meaningless information, forgetting is initially rapid and then slows down gradually over time. More than half of the memory loss occurs within the first hour after learning. He represented his findings in a graph that is now known as the **forgetting curve**.



Measures of retention: recall, recognition, relearning

When measuring retention, sensitivity refers to how well a method is able to show that the information has actually been stored in memory. A more sensitive measure of retention will be capable of registering a low intensity or strength of retention, which would be missed by a less sensitive measure.

The **recall** method involves being required to remember information with few, if any, cues, aids or hints available which may facilitate retrieval, rendering it the least sensitive of the three measures.

Free recall requires the individual to remember items without any cues, e.g. short-answer questions in an examination. Items may be retrieved in any order.

Serial recall entails reproducing items from a list or sequence in the same order as they were presented.

For **cued recall**, some hint is available to help trigger recall.

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The **recognition** method is more sensitive than the recall method as individuals are able to select or identify previously encountered material to be remembered from given alternatives or a set of distractor items. Therefore, this method provides more cues to aid recall, e.g. multiple-choice questions or the use of police line-ups or 'mug-shots' for witnesses.

Relearning is the most sensitive measure of retention as it is able to measure some memory of information even when an individual is unable to do so through recall and recognition. This is achieved by relearning information previously memorised and measuring the amount of time or learning trials saved in this process via a savings score. If an individual learns more rapidly the second time around, it is inferred that they remember information from previous learning, even if they cannot consciously recall these memories.

Measuring relearning

Calculating a savings score

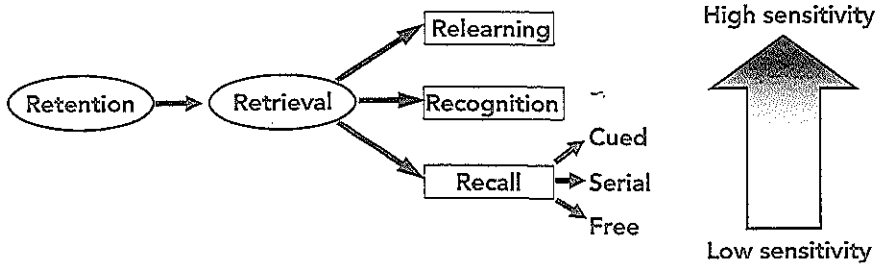
Relearning can be measured using the method of savings which is calculated as follows:

$$\text{Saving} = \frac{\text{(original trials)} - \text{(trials for relearning)}}{\text{original trials}}$$

For example, it takes you 9 trials to learn the steps to the tango. Five years later, at dancing lessons, it takes 6 trials. What is the saving percentage?

$$\text{Saving} = \frac{9 - 6}{9} \times \frac{100}{1}$$
$$= 33.3\%$$

Relative sensitivity of the measures of retention



Quality of encoding

Elaboration involves the processing of new information by making it more meaningful in order to aid its integration with other previously stored information.

An individual could enhance their memory using elaborative techniques by thinking up examples of concepts they wish to memorise. Alternatively, they may also utilise self-referencing. This involves associating the word to be remembered with a personal situation. For example, if the word to be remembered is 'chicken', the individual may remember the last time they ate a roast chicken.

By adding further information to that which needs to be remembered, elaboration makes the codes used for long-term memory more distinctive and unique, and therefore easier to locate during the retrieval process of long-term memory.

The use of context-dependent and state-dependent cues

A **retrieval cue** is a hint or suggestion that can initiate the retrieval process for accessing information from long-term memory. Such cues can lead to redintegration, which is a form of remembering which occurs when a cue unlocks a rapid chain of memories.

Memory works better in the context of original learning. **Context cues** involve

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information surrounding a stimulus at the time of learning, such as the setting, surrounding circumstances and behaviour, which act as triggers for memory when the context in which recollection occurs is of a similar nature. For example, to prepare for the end-of-semester examination it would be better to engage in morning study, under quiet conditions, and use similar timing, location and structure to that of the examination than to perform late study, under noisy conditions, and with no real structure or timing. A particular context makes people think about information in specific ways that may not occur elsewhere, leading to better recall.

State-dependent cues tend to help an individual to remember something when they are in the same physical or mental state as during the original learning or experience.

In preparing for the exam, the state of alertness for the first individual mentioned above and the fact that no food and drink were consumed during study would place them in a similar state to that of the examination. Conversely, artificial alertness, from consuming large amounts of coffee which would be unavailable in the examination would detract from the formation of state-dependent cues. If during 'Swot Vac' a student studied until late at night and slept in the following morning, their bodily state may be further under-aroused for the task as they would normally be asleep at the time of the examination.

The use of mnemonic devices

Cued recall aids in accessing information stored in memory by utilising a meaningful sign or hint to facilitate retrieval. An example of this is priming, which activates hidden memories through giving an individual limited cues such as the first letter of a word to be recalled. A cue will be an effective aid to retrieval if it is stored as part of the original memory.

More often, though, some type of **mnemonic device** is used. A mnemonic is a strategy/technique used to improve an individual's memory, usually by adding information to the items to be remembered in order to make them more meaningful. Retrieval is simplified because organisation is enhanced. The information memorised is changed into a form in which it can link in or fit in more easily with the information already stored in memory.

Some mnemonics employ **imagery** to enhance memory by linking a relevant mental picture/representation or idea with the concept to be remembered. For example: 'Stal**ac**tites hold on **tight** to the roof of caves, whereas stalag**mites might** grow up to meet them', or 'pra**c**tice contains **ice** which is a noun, whereas practise contains **is**, which is a verb'. In each case, parts of the term are paired with images about the relevant concept or attribute to be remembered.

Association, on the other hand, refers to the assimilation of new material by relating or connecting it to already learned information, thereby linking it into existing semantic networks in our long-term memory. The more things you can connect with a desired memory, the stronger that memory will be.

The repetitive use or rehearsal of memory-enhancing techniques helps us to recall the necessary information.

Acronyms

An **acronym** is a method of chunking information for retention by creating a pronounceable word using the first letters of a group of words e.g. AIDS (Acquired Immuno-Deficiency Syndrome), WHO (World Health Organisation), ANZAC (Australian and New Zealand Army Corps), QANTAS (Queensland And Northern Territory Air Service).

Some acronyms may form a series of words or appear to be a person's name, such as 'Roy G. Biv' (the colours in the visible spectrum). Through regular use, many acronyms have now become accepted as words themselves, for example, 'scuba' and 'laser'.

Note: an acronym **must** be pronounceable. Abbreviated names of organisations, such as RACV or IBM are not automatically acronyms, especially if they are said as a series of letters.

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Acrostics

Acrostics involve the use of word associations where the first letter of each word in a list to be remembered is incorporated into a phrase which can be more easily recalled, for example 'A Big Man Sings Very Well!' (the key functional areas within the brain you needed to know in Area of Study 1).

> **Acronyms** use initials to form a **name** or word (the suffix '-nym' = word or name), whereas **Acrostics** take initials from each concept to form a sentence.

Peg-word method

The **peg-word method** employs imagery or visualisation along with a list of previously-learned words that act as 'pegs' from which the items to be remembered are 'hung'.

The peg words usually rhyme with the number designating the order of the item in the list to be remembered, for example: one is a bun, two is a shoe, three is a tree, four is a door, five is a hive, six is sticks, seven is heaven, eight is a date, nine is a vine, ten is a hen.

The list and the peg words are paired in such a way that images combining the two are created such that an association (visual or otherwise) is made between them, and it is these images that act as retrieval cues for the list of items to be remembered. For example, for the memorised peg-word 'one is a bun', an item to be remembered, 'steel wool', could be paired with the word bun by visualising a pad of steel wool placed between the two halves of a bun. The peg-word 'bun' would then act as a cue for retrieving the item 'steel wool'.

Narrative chaining

> Narrative = Story

Narrative chaining, a form of the link method, is a way of remembering a list of unrelated items by creating a story (or song) that links the concepts together in some ordered manner.

For example, a story to remember the words 'cat, ball, room, book, memory, essay, Macbeth, Friday' could be 'The *cat* played with a *ball* of yarn in the living *room*, while her owner read a *book* about *memory* before writing an *essay* on *Macbeth* that was due on *Friday*.'

Method of loci

> Loci → Location

The **method of loci** uses a familiar sequence of places or locations (such as rooms in your home or landmarks on your way to school) or points on an easily imagined scene or figure (e.g. the back of your hand) as a series of cues with which items to be recalled can be associated. This involves visualising an image linking each item to be remembered with each of the locations in the sequence. By retracing the route in your head and examining the images, they cue recall of the items so that you can reconstruct the concepts in order. This technique is best for serial recall for lists of items in a particular order.

Rhymes

Rhymes are phrases that end in a similar sound to the end of another phrase with which it is paired. Sometimes rhymes may use repetitive sounds within a phrase or sentence. These phrases, when recited with a certain rhythm and/or linked with music, become 'catchy' and thus easier to remember.

Examples show how they can be employed to recall general facts (e.g. the number of days in the months: 'Thirty days has September, April, June and November ...'), historical information (e.g. 'In 1492, Columbus sailed the ocean blue'), or English spelling rules (e.g. '*i* before *e* except after *c*.').

Advertisers often apply this method to make their jingles and slogans more memorable.

Improve your memory

- Study repeatedly to boost recall (relearning).
- Spend more time rehearsing and thinking about the material. The more an idea is encountered, the stronger its representation in memory.
- Make material personally meaningful (link into semantic network).

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- Use mnemonic devices and activate retrieval cues.
- Minimise interference.
- Test yourself frequently
  - to rehearse the material
  - to determine what you do not know.

Eyewitness testimony (Loftus)

Eyewitness testimony is a readily accepted form of evidence within the criminal justice system. Unfortunately, eyewitness evidence is not infallible.

To accurately remember the details about a crime, accident or other significant event, the witness must first encode the information. What is encoded depends on where an individual's attention is directed at a particular time and what is taken in or perceived.

This may be due to a number of dynamics, such as:

- violence distraction, where people have a better memory for non-violent events than for violent events
- stress (high levels of arousal and/or fear) experienced by witnesses when violence is used, threatened or implied. Heightened arousal due to the 'fight-or-flight' response often leads to a narrowing of focus on the criminal and their actions, to the detriment of other peripheral information, as we appraise the threat in the situation
- 'weapon focus', whereby, if a weapon is present during an incident, the witness' memory for details other than the weapon is impaired because they concentrate their attention on the weapon and not on other details of the event
- trauma, which may impair a witness' ability to remember details of the event because of intrusive thoughts (such as 'I could have been killed!') that can break their concentration. If the trauma experienced was severe enough, the witness may not be able to remember certain details because of *motivated forgetting*. Many victims of crime experience memory blackouts due to post-traumatic stress disorder. Retrieval of information might be improved by remembering what was experienced emotionally during an event utilising *state-dependent retrieval cues.*

The longer the delay between the event and our attempts to remember it, the less complete and accurate the account will be (Ebbinghaus, 1885). According to the decay theory, it would be expected that some information would be lost as a person's memory of accidents or crimes would fade when there is a long delay between witnessing a crime and being asked to retrieve it.

If such gaps do occur in a person's memory, they may **reconstruct** it. This may involve filling in the missing bits of information by making up some of the details in order to achieve a memory that 'makes sense' according to our attitudes, beliefs and expectations about a particular event or person. Alternatively, memory for details that are inconsistent with our knowledge and beliefs about the world can subtly change to fall in line with our expectations. Allport and Postman (1947) found that prejudice influenced the recall of whether a black or white person was holding a cut-throat razor in a picture.

Loftus has argued that, because of the reconstructive nature of memory, eyewitness memory is extremely unreliable because information from external sources received *after* the witnessed event can be incorporated into memory, thereby creating **retroactive interference** on the memory of that event.

The subtle use of language in questions can influence witnesses by suggesting a particular response. A number of research studies have shown that people's memories of events can be affected by **leading questions** which direct the witness towards the response desired by the questioner. Further to this, the use of **misleading questions**, which are intended to cause a witness to respond in a way that the questioner knows does not fit the facts, can direct the witness to a particular re-interpretation of the event. The phrasing of such questions not only decrease accuracy levels, but can cause the information suggested or implied by such questions to be subsequently incorporated into memory. For example, if we are asked 'Did you see the red car?', we may not have been aware that the car was red, but later come to 'remember' that car as red.

In one experiment, participants were shown a film of a car accident and then asked 'About how fast were the cars going when they collided into each other?' Alternative versions of the question used the words 'smashed', 'bumped', 'hit' or 'contacted'. Although the words all refer to the coming together of two objects, they differ in what they imply about the speed and force of impact. Higher estimates of speed were reported when the participants were asked 'How fast were the cars going when they smashed into each other?' than when the verb 'hit' was used. When participants were asked whether they saw any broken glass at the accident, 14 per cent of the 'hit' group recalled glass, whereas 32 per cent of the 'smashed' group recalled glass (there was, in fact, no glass visible). It was concluded that the wording of the question had biased the memory of the participants (Loftus and Palmer, 1974).

In another experiment, Loftus and Zanni (1975) showed participants a film of a car accident and got more participants to incorrectly recall seeing a broken headlight by asking 'Did you see *the* broken headlight?' than asking 'Did you see *a* broken headlight?'

In an experiment into the **misinformation effect**, participants were shown a video in which a car went past a 'Stop' sign and then asked about the car's speed when it passed the 'Yield' ('Give way') sign. When later asked whether they had seen a 'Stop' sign, a 'Yield' sign or a 'One-way' sign, participants who had been given the false information tended to report having seen the 'Yield' sign. (Loftus, Miller and Burns, 1978).

In a later study, researchers got over a third of their participants to say they shook hands with Bugs Bunny at Disneyland by implanting the impossible suggestion – Bugs Bunny is not a Disney character (Loftus et al. 2002). The study demonstrates the reconstructive nature of memory and that it is possible to convince people that they have witnessed something that has not actually happened.

Loftus also demonstrated that misleading questions do not always influence memory. For example, memory will remain unaffected if the misinformation or misleading question is blatantly incorrect. It is easier to mislead the memory about minor or plausible details rather than major details in an event.

Loftus and many of her colleagues believe that memories are constantly being updated to fit 'post-event information' such as events, details, and comments that are experienced later. She proposes that we are often unable to distinguish the source of our memories, which can result in the incorporating misinformation into memory along with accurate information encoded at the time of an event.

Much of the research into eyewitness accuracy has been based on laboratory studies. While their findings are helpful for interpreting information from an operational setting, they are a poor substitute for the actual conditions which victims and witnesses endure. Hence more empirical research is needed based on actual cases.

Field studies allow less control over what is witnessed but have the advantage of being more realistic and can include factors that cannot ethically be modelled in the laboratory, such as the effects of violence and stress.

Improving the accuracy of eyewitness testimony

Recognition is better than recall. Even if a witness cannot accurately describe details of an event, it does not mean they cannot identify or recognise objects or people.

One approach police use is to get the witness to look through photographs (or 'mug shots') of known criminals to find the suspect.

Another technique is to place a suspect in an identification parade, or line-up, with five or six innocent people. The witness, usually behind a one-way mirror, is asked to view each person in turn and to make a positive identification if they recognise the person as the culprit.

However, false identification of an innocent person within a police line-up is possible, especially if there are small numbers in the identification parade. Informing the witness that there could be a number of

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line-ups and that there is a large possibility that the culprit is not present should remove the 'one of these individuals must be guilty, otherwise I would not be here' mentality. In doing so, identification will no longer be based purely on similarity defaults, but true recognition. This will alleviate the selection of innocent individuals simply because they were of a similar appearance to that of the criminal (Wells, 1993).

In addition to this, environmental features or conditions can provide context-dependent cues to help access memories that were formed within that setting. Therefore, if an eyewitness was having trouble retrieving details of an incident, investigators may take them back to the scene of the crime as the cues within the environment may help locate and retrieve related memories (cued recall is more sensitive than free recall).

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Glossary of terms

Acetylcholine
A neurotransmitter within the brain which helps regulate memory.

Acoustic processing (also known as phonological processing, phonemic processing)
A moderate level of processing such that information is retained according to what it sounds like.

Acronym
A method of chunking information for retention by creating a pronounceable word using the first letters of a group of words, e.g. AIDS.

Acrostics
A mnemonic device involving the use of word associations where the first letter of each word in a phrase serves as a retrieval cue for items within a list to be remembered.

Alzheimer's disease
A progressive condition in which nerve cells in the brain degenerate and the size of the brain substance shrinks, particularly in the hippocampus and related areas of the mid-brain. Alzheimer's disease is the single most common cause of dementia, with deterioration of memory (beginning with short-term memory abilities) being the most widely recognised feature of the disease. Other features of the disorder include the patient becoming disoriented as to time and place, declined in concentration and numerical abilities, and increased in frustration, unpredictable mood swings and changes in personality.

Amnesia
Loss of the ability to memorise information and/or to recall information stored in memory, usually due to damage to the hippocampus.

Anterograde amnesia
Memory loss for events that occur after a person sustains an injury to the brain. Memory of events which have occurred prior to the damage still remain intact.

Articulatory (or phonological) loop
The aspect of Baddeley and Hitch's (1974, 1986) model of working memory responsible for storing speech-based information, comprised of a phonological memory store, which can hold traces of acoustic or speech-based material for about two seconds, unless it is maintained through the use of articulatory sub-vocal rehearsal.

Articulatory sub-vocal rehearsal
The sub-system within the phonological loop that acts as an 'inner voice', reviving memory traces by repeating the series of words (or other speech elements) on a loop to prevent them from decaying.

Association
The assimilation of new material by relating/connecting it to already learned information.

Capacity of memory
How much information can be stored within memory. The amount of data that can be held varies between the different levels of memory.

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Central executive
The most important aspect of Baddeley and Hitch's (1974, 1986) model of working memory, which is described as very active and responsible for the selection, initiation and termination of processing routines (such as encoding, storage and retrieval).

Chunking
A method of increasing the capacity of the short-term memory by grouping or combining small bits of information into units. This enables an individual to remember seven plus or minus two 'chunks' or slabs of information, rather than seven plus or minus two units.

Cognitive slowing
A phenomenon characterised by slower neural processing, whereby the elderly take longer to encode information for storage and consolidate material into their long-term memory.

Consolidation theory
Proposes that in order for new information to be transferred effectively from short-term to long-term memory, there needs to be a time period in which these memories are able to fortify or stabilise without being disrupted. During this time, physical and psychological changes take place as the brain organises and restructures information in order to enable permanent storage of the new information.

Context dependent cues
Information surrounding a stimulus at the time of learning, such as the setting, surrounding circumstances and behaviour, which act as triggers for memory when the context in which recollection occurs is of a similar nature.

Cued recall
Accessing information stored in memory by utilising a meaningful sign or hint to facilitate retrieval.

Decay theory of forgetting
Proposes that memory traces in the brain containing stored memories disintegrate or fade over time if they are not used. This results in an individual forgetting the stored information; it gradually erodes from disuse.

Declarative memory
A sub-type of long-term memory concerned with specific facts or events which can be brought consciously to mind and usually be communicated to others. Declarative memory may be further divided into two sub-categories, semantic memory and episodic memory.

Dementia
A condition characterised by a severe decline in mental functioning, especially memory loss, due to progressive destruction of brain tissue.

Digit-span test
A measure of attention and short-term memory which tests the recall of a series of digits.

Duration of memory
How long information can be stored within memory. The amount of time that data can be held varies between the different levels of memory.

Echoic memory
A type of sensory memory for auditory information. It has a limited duration of approximately 3–4 seconds.

Elaboration
The processing of new information by making it more meaningful to aid its integration with other previously stored information.

Elaborative rehearsal
The association of new information with information that has already been stored in long-term memory or with other new information to aid encoding.

Encoding
The conversion of information to be remembered into a useable form which the brain is able to store and represent in memory.

Engram
Also called memory traces, the hypothesised chemical change in the brain resulting from the storing of memory information.

Episodic buffer
The component of Baddeley's (2000) updated model of working memory, which provides temporary storage of representations that incorporate phonological, visual, spatial and other information to form integrated, meaningful units with time sequencing (or chronological ordering).

Episodic memory
A form of declarative memory which contains autobiographical information about personal events and experiences in an individual's life and the contexts in which they occurred.

Eyewitness testimony
A legal term referring to an account given by people of an event they have witnessed, including the identification of perpetrators, details of the crime scene, etc. These are generally used in criminal cases whereby individuals have to give a description of a crime to the police or a court. Elizabeth Loftus has demonstrated that memory is reconstructive and that eyewitness testimonies are unreliable.

Forgetting
The apparent loss of information or the inability to access previously encoded information within memory.

Forgetting curve
Ebbinghaus claimed that when an individual memorises meaningless information, such as novel nonsense syllables, forgetting is initially rapid and then slows down gradually over time. More than half of the memory loss occurs in the first hour.

Free recall
A method of accessing the memory of information without the provision of any cues. Items to be remembered may be recited in any order.

Hippocampus
A seahorse-shaped brain structure within the temporal lobes associated with encoding information and transferring it from short-term memory to long-term memory.

Iconic memory
A type of sensory memory involving memories of a visual nature. The duration of visual images in iconic memory is approximately 0.3 of a second.

Imagery
A strategy to enhance memory by linking a relevant mental picture/representation or idea with the concept to be remembered.

Interference theory of forgetting
Accounts for the forgetting of information stored in long-term memory due to other memories contesting with the retrieval of what an individual is trying to remember. This is more likely to occur if the interfering memories are similar in nature to the information an individual is trying to recall.

Leading questions
Questions which can, either by their form or content, influence eyewitnesses by suggesting or implying a particular response.

Long-term memory (LTM)
A relatively permanent memory system which has an infinite capacity for storing information for an extensive period of time.

Maintenance rehearsal
The mental recitation or repetition of information, so that it can be retained in short-term memory for longer than the usual maximum duration of approximately twenty seconds.

Memory
An active, information-processing system that receives, organises, stores and recovers information.

Memory trace
A physical or chemical trace, or impression, that is formed in the brain when something new is learned.

Method of loci
A mnemonic technique for improving memory which utilises a familiar sequence of locations as a series of cues to aid retention of a list of items to be memorised.

Method of savings
The most sensitive measure of retention. It is based on relearning information that has been previously memorised, in order to measure the time saved from previous learning.

Misinformation effect
The phenomenon demonstrating the reconstructive nature of memory whereby research participants incorporate false information received after an event into their description of the original event.

Misleading questions
Questions which are intended to cause a witness to respond in a way that the questioner knows does not fit the facts, and which can direct the witness to a particular re-interpretation of the event.

Mnemonic device
A strategy or technique used to improve an individual's memory, usually by adding information to the items to be remembered in order to make them more meaningful. Examples of mnemonics are the method of loci and narrative chaining.

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Motivated forgetting theory
Also called repression, the theory is based on Freud's observation that individuals unconsciously block out painful or unpleasant memories from ordinary waking consciousness. Later events may bring these memories back to the surface, or else they may emerge in dreams or nightmares.

Narrative chaining
A mnemonic device that aids in the recall of unrelated items by linking them as parts of a story.

Nodes
Key concepts within our semantic network.

Nonsense syllables
Contrived three letter words used to test memory. They are meaningless and usually consist of a vowel surrounded by two consonants.

Ordered recall
The access of items to memory in the exact sequence in which they were presented.

Organic amnesia
Memory loss which may be attributed to brain damage as a result of a stroke, malnutrition, brain surgery, alcoholism (as in Korsakoff's syndrome) or a disease such as Alzheimer's disease.

Peg-word method
A mnemonic technique involving imagery or visualisation along with a list of previously-learned words that act as 'pegs' from which the items to be remembered are 'hung'. The peg words usually rhyme with the number designating the order of the item in the list to be remembered, for example 'one is a bun', 'two is a shoe' and so on. The list and the peg words are paired in such a way that images combining the two are created, and it is these images that act as retrieval cues for the list of items to be remembered.

Phonological loop
The aspect of Baddeley and Hitch's (1974, 1986) model of working memory that is responsible for storing speech-based information. It comprises a phonological memory store, which can hold traces of acoustic or speech-based material for about two seconds, unless it is maintained through the use of articulatory sub-vocal rehearsal.

Primacy effect
Part of the serial position effect, explaining superior recall for items at the beginning of a list due to the fact that they have been rehearsed and are more likely to have been stored in long-term memory.

Proactive interference
Occurs when previously learned information interferes with an individual's ability to remember newly learned information.

Procedural memory
A type of long-term memory involving thought processes and skills which enable an individual to carry out a course of action. Examples include rollerblading, or tying your shoelaces.

Recall
A measure of long-term memory which involves the recollection of information with few if any cues, aids or hints available which may facilitate retrieval.

Recency effect
Part of the serial position effect, explaining superior recall for seven plus or minus two items at the end of a list, due to the fact that they are still in short-term memory.

Recognition
A measure of long-term memory which involves the identification of the correct information amongst a set of distractor items. An example of this is a multiple-choice test.

Reconstructive memory
An explanation of memory which states that when a person recalls past experiences they fill in missing bits of information by making up some of the details, or they incorporate information received after the event in order to achieve a memory that 'makes sense'.

Rehearsal
Silently repeating information in order to maintain it in short-term memory or to aid its transfer into long-term memory.

Relearning
Learning something again that was learned previously in order to measure the memory of prior learning via a savings score.

Repression
The label given, in Freudian theory, to the mental defence mechanism by which a person unconsciously protects themself from remembering unacceptable or painful information by pushing it out of consciousness.

Retention
Holding onto information within memory over time; another term for storage of information.

Retrieval
The process of recovering information that has been stored in long-term memory.

Retrieval cue
A hint or suggestion that can initiate a retrieval process for accessing information from long-term memory.

Retrieval failure theory (also known as cue-dependent forgetting)
This occurs when an individual is unable to access information from long-term memory, even when they are certain they know the information. This is due to the absence of an effective retrieval cue. Forgetting of this type is not permanent – information may be accessed once a correct cue is recalled.

Retroactive interference
Occurs when newly learned information interferes with an individual's ability to remember previously learned information.

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Retrograde amnesia
A type of amnesia which occurs when damage sustained to the brain affects memories for events that occurred *before* the damage occurred. This memory loss may affect the recall of memories which are moments, days, weeks, months or even years old.

Semantic memory
A type of declarative memory which involves specialised knowledge of factual information about the world. This includes general knowledge, academic knowledge of the variety learned at school, as well as the meaning of words.

Semantic network theory
A proposition that long-term memory is organised systematically into hierarchical networks of concepts (nodes), arranged as interrelated categories and sub-categories. Information within the nodes is interconnected via meaningful links.

Semantic processing
The deepest level of processing information by creating meaningful associations in order to understand the items to be remembered.

Sensory memory
Items detected by the sensory receptors which are retained temporarily in the sensory registers. These sensory registers have a large capacity for unprocessed information, but are only able to momentarily preserve extremely accurate images (traces) of sensory information; just long enough for relevant details to be attended to and transferred to short-term memory. The two types of sensory memory that have been most extensively explored are iconic (visual) memory and echoic (auditory) memory.

Serial list
A list of items such as numbers, nonsense syllables or words which are required to be recalled in a specific sequence.

Serial position effect
The recall of items in a serial list is superior for items at the beginning of the list due to the primacy effect, and for seven plus or minus two items at the end of the list due to the recency effect.

Serial recall
The reproduction of information stored in memory in the order in which it was presented.

Short-term memory (STM)
A type of memory which is also referred to as 'working memory' as it allows an individual to manipulate information contained in sensory or long-term memory. It has a limited capacity of seven plus or minus two items and a duration of approximately twenty seconds.

State-dependent cues
Triggers which enhance memory because an individual's physical or mental state at the time of retrieval is the same as during the original learning or experience.

Storage
The retention of information in memory over time.

Structural processing
Shallow processing of information on a superficial, perceptual level, focusing on its physical attributes or appearance.

Suppression
The process by which a person consciously tries to forget unacceptable or painful information by pushing it out of consciousness.

'Tip-of-the-tongue' phenomenon
A state of memory which occurs when an individual is confident that they know something, but are not quite able to access it from memory at that particular point in time. The individual may be able to describe characteristics of the item (such as the first letter, length, what it looks like, etc.), but not the actual item (word/term/name) itself. As the apparently lost information can, over time, eventually be retrieved from long-term memory, this phenomenon suggests that other factors rather than decay of memory traces over time may be responsible for memory loss. It may be that, at the time, the right cue was unavailable to bring the memory back out of storage.

Trace-dependent forgetting
Forgetting which is explained by the gradual disintegration of memory traces over time unless they are activated by occasional usage.

Trigram
A meaningless cluster of three letters (see nonsense syllables).

Vascular dementia
A condition characterised by a decline in mental functioning resulting from reduced blood flow to the brain's nerve cells caused by a series of strokes or changes in the blood supply to the brain.

Visuo-spatial sketchpad
The aspect of Baddeley and Hitch's (1974, 1986) model of working memory responsible for the temporary storage and manipulation of visual and spatial information.

Working memory
A function of short-term memory in which small amounts of information can be processed, such as mental arithmetic, dialling a telephone number and remembering a brief list of items.

> Definitions for the research terms associated with this unit can be found at the end of Chapter 3.

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Revision checklist – Memory

The following checklist of Learning Outcome 2 will enable you to tick off the key concepts and skills you have revised to ensure that you have thoroughly reviewed the content in Area of Study 2. Please note that the key knowledge and skills will not be assessed separately (VCE Study Design, 2009) and therefore have been integrated to aid your revision process.

On completion of this unit, you should be able to compare theories that explain the neural basis of memory and the factors that affect its retention, and to evaluate the effectiveness of techniques for improving and manipulating memory. To achieve this outcome, you will need to be able to demonstrate knowledge and skills pertaining to the concepts outlined below.

Tick (✓) the box once you are confident of your understanding of each concept.

The function of the nervous system in memory	
The role of the neuron in memory formation (Kandel)	
The function of the hippocampus	
Consolidation theory	
Memory decline over the lifespan	
Organic forms of forgetting	
Amnesia resulting from brain trauma and neurodegenerative diseases	
• Anterograde amnesia	
• Retrograde amnesia	
Dementia	
Alzheimer's disease	
Models for explaining human memory	
Levels of processing (Craik and Lockhart)	
Multi-store model of memory (Atkinson and Shiffrin)	
Sensory memory	
• Iconic (visual) memory	
• Echoic (auditory) memory	
Short-term memory (STM)	
• Capacity	
Effects of chunking	
Effects of rehearsal	
• Maintenance rehearsal	
• Elaborative rehearsal	
Long-term memory (LTM)	
• Procedural memory	
• Declarative memory	
• Episodic memory	
• Semantic memory	
Semantic network theory	
Serial position effect	
• Primacy effect	
• Recency effect	

Working memory (Baddeley and Hitch)	
• Central executive	
• Visuo-spatial sketchpad	
• Episodic buffer	
Psychological theories of forgetting	
Retrieval failure theory	
Decay theory	
Interference theory	
• Proactive interference	
• Retroactive interference	
Motivated forgetting (Freud)	
• Repression	
• Suppression	
Manipulation and enhancement of memory	
The forgetting curve (Ebbinghaus)	
Quality of encoding	
The use of context-dependent and state-dependent cues	
The use of mnemonic devices	
• Acronyms	
• Acrostics	
• Peg-word method	
• Narrative chaining	
• Method of loci	
• Rhymes	
Eye-witness testimonies (Loftus)	

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